BED ALLOCATION IN HOSPITALS – A CASE STUDY

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ABSTRACT

Due to increase of patient inflows and types of medical services demanded over a time period, the hospital administration is faced with the problem of assigning bed for various medical services in a hospital. The objective of this study is to allocate the number of beds in hospital wards compatible with the service level desired by the hospital administration.

Key words: Queuing model, health care, queue discipline, arrivals,services.

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1. INTRODUCTION

Ward beds are primary resources under the control of hospital management. We develop a method fro determining an optimum distribution of beds in a ward by assuming that ward patients can be classified into two categories that admissions follow passion distribution, and that length of stay in the ward follows the negative exponential distribution. Bed management strategies employed in practice or discuss in the literature do not explicitly consider the stochastic, as well as relevant cost dynamics, involved in the process. If beds in a ward are to be used efficiently, one of the many requirements as that admitting procedures be designed so that the total or average time a bed remains empty is minimized. If we assume that all patients waiting to be admitted to the ward could benefit equally from a bed-day and that delays do not seriously inhibit the outcome of in-patient treatment, the admitting schedule can be relatively simply designed to achieve a high level of average percentage occupancy or bed usage. However, in a more complex system where waiting time prior to admission is an important determinant of treatment outcome for some cases but not for others, it might be necessary to tolerate a reduced occupancy to ensure that, with an acceptable probability, a bed will be available for randomly arriving urgent or special cases. We present a queuing model useful in devising an admission policy in a ward for different types of patients and optimize it with respect to an objective function that is a hybrid of the traditional measure of efficiency-occupancy maximization-and a new one-the minimization of unsatisfied needs.

Ahsan et al.[2004] describes healthcare performance by analytic hierarchy process. **Basson et al.[2006]** have developed a predicting patient non-appearance for surgery as a scheduling strategy to optimize operating room efficiency. **Brown et al. [2007]** have developed an application of a quantitative risk assessment method to emergency response planning. **Butler et al. [2005]** describes the utility of returns to scale in DEA programming. **Dey et al. [2004]** describes the performance measurement of intensive care services in hospitals. **Dexter et al. [2002]** have developed a schedule in elective surgical cases into specific operating rooms to maximize the efficiency of use of operating room time. **Embleton et al. [2001]** have developed a postnatal malnutrition and growth retardation an inevitable consequence of current recommendations in preterm infants. **Hariharan et al.[2004]** have developed a new tool for measurement of process - based performance of multispecialty tertiary care hospitals.

Kwak et al. [2002] described a business process reengineering for health-care system using multicriteria mathematical programming. **Light [2003]** have developed a universal health care lessons from the British experience. **Marcon et al. [2003]** have developed a operating theatre planning by the follow- up of the risk of no realization. **Rodwin et al. [2003]** describes the health care system under French national health insurance. **Shiau et al. [2006]** has described the life cultivation of nursing education touched by care and concern . **Taiwan Nursing Accreditation Council**, **[2007]** describes the accreditation manual of the Taiwan Nursing Accreditation Council. **Woodhouse [2007]** has developed the strategies for healthcare education.

In this paper we used a queuing model to allocate the number of beds in hospital wards compatible with the service level desired by the hospital administration.

2. DATA OF THE PROBLEM

This case study was carried out in Government Hospital situated in Hyderabad. This hospital is one of the biggest Government Hospitals in Hyderabad having 595 beds and various departments. On an average 463.2 patients are examined every day in the O.P.D. of the hospital. Data regarding arrival rate [admission rate]and service time [discharge rate] including waiting [period for which patients remain in the hospital] time was collected over a period of one month. The data was collected for the patients with initial distribution among various departments such as acute medical ward, acute surgical ward and intensive care unit. The relevant information is given in Table I.

Table I

Acute medical ward	**30 beds**
Acute surgical ward	**30 beds**
Intensive care unit	**14 beds**
Total	74 beds

3. Queuing model

The multi-channel queuing model is used to evaluate the number of beds in each ward. Assuming first come, first served queue discipline, Poisson arrivals of patients and exponential service times, the following results have been used from queuing theory.

The probability that there is no patient waiting or being served on bed is:

$$P_0 = \left(\sum_{n=0}^{s-1} \frac{1}{n!} (\lambda/\mu)^n + \frac{1}{s!} (\lambda/\mu)^s \left(\frac{s\mu}{s\mu - \lambda} \right) \right)^{-1}$$

The average number of patients waiting for admittance is:

$$Lq = \frac{\rho (s\rho)^s}{s!(1-\rho)^2} P_0 = \frac{\lambda\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 \qquad (\text{since } \rho = \lambda/s\mu)$$

The average number of patients being served on beds plus those waiting for admittance is:

$$L_s = \frac{\lambda\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 + \lambda/\mu = L_q + \lambda/\mu$$

The average waiting time the patient must wait before being admitted is:

$$W_q = \frac{\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 = L_q/\lambda$$

The expected time spent in waiting for admittance plus spent on bed is :

$$W_s = \frac{\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 + \frac{1}{\mu} = W_q + 1/\mu$$

Where,

λ = The number of patients arriving per day.

μ = The number of patients served on each bed per day.

s = Total number of beds.

4. Results and Discussion

For each ward studied, the arrival of the patients and length of the stay was calculated from the appropriate records and arranged to yield λ and μ. In the intensive care unit, it was found that the average number of patients arriving per day (λ) worked out to be 0.43. The values of P_0, L_q, L_s, W_q, W_s were calculated for different values of s leaving out those values for which the condition $\lambda/s\mu < 1$ is not applicable. The results are summarized in Table II.

In intensive care unit for the available strength of 14 beds as per Table I, the number of patients waiting for admittance is 1.087 patients per day and the expected waiting time is 0.2303 day per patient, *i.e.* 5 hours 31.5 minutes per patient. It is a glaring instance when such a high rate of waiting time may cause loss of one's life in certain cases which is to some extent is met by early and un-scheduled discharge of the patients. Therefore, the only course left was to increase the number of beds so as to reduce the time in waiting for admittance. Twenty three (23) beds were recommended in intensive care unit. Proceeding similarly for other wards, 30 beds each were recommended in acute medical and acute surgical wards thus increasing the total number of beds in three wards to 83 from its initial strength of 74.

Table II: Varying Queuing Characteristics in Intensive Care Unit.

S	P_0	L_q	L_s	W_q	W_s

11	$(3330106.8)^{-1}$	468.16388	479.14062	99.187263	101.51284
12	$(108958.79)^{-1}$	7.3751392	18.351883	1.5625295	3.8881109
13	$(75091.099)^{-1}$	2.5038149	13.480559	0.5304693	2.8560507
14	$(65412.275)^{-1}$	1.0869604	12.063704	0.2308882	2.5558696
15	$(61595.979)^{-1}$	0.5110468	11.487791	0.1082726	2.433854
16	$(59915.185^{-1}$	0.2466284	11.2233372	0.0522518	2.3778332
17	$(59144.968)^{-1}$	0.1192131	11.095957	0.025257	2.3508384
18	$(58789.264)^{-1}$	0.0569578	11.033702	0.0120673	2.3376487
19	$(58626.422)^{-1}$	0.0266891	11.003433	0.0056545	2.3312359
20	$(58553.197)^{-1}$	0.012206	10.98895	0.002586	2.3281674
21	$(58521.028)^{-1}$	0.005432	10.982176	0.0011508	2.3267322
22	$(58507.263)^{-1}$	0.0023481	10.979092	0.00049748	2.3260789
23	$(58501.538)^{-1}$	0.00098489	10.977729	0.00020864	2.32579
24	$(58499.225)^{-1}$	0.00040064	10.977145	0.00008487	2.3256663
25	$(58498.318)^{-1}$	0.00015804	10.976902	0.000033475	2.3256149

The above results hold good under the steady state condition $\lambda/s\mu < 1$.

5. CONCLUSION

In this paper we used a queuing model to allocate the number of beds in hospital wards compatible with the service level desired by the hospital administration to fulfill the needs of patients who is admitting into hospital suffering with various health problems. It can also be applied to all types of hospitals to verify equally marked improvement has achieved or not for application study, ideally one comprising all the departments involved in admission and assignment planning.

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